Outage performance analysis of NOMA over log-normal fading distribution in presence of CSI and SIC imperfections

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ABSTRACT

The evolution of wireless communication networks has introduced various applications that require massive device connectivity and high spectral efficiency. Non-orthogonal multiple access (NOMA) technique is one of the most promising technologies to perform efficiently data transmission. The NOMA technique can allocate the same resource block for two users by super-imposing signals. At the receiver, the signals are separated by performing successive interference cancellation (SIC) technique. For efficient data transmission, the fading and shadowing effects of channels also play a pivotal role. Many researches have considered Rayleigh, Rician, Nakagami-*m*, and other fading channels in various perspectives. In our paper, a system model based on a NOMA network with two users over log-normal fading distribution in the presence of channel estimation errors and SIC imperfections is proposed. The performance is analyzed in terms of outage probability and simulations are performed with the assistance of Monte-Carlo simulations. The obtained results shown the effectiveness in comparison with the traditionally used fading distributions. The same analysis is also performed in various scenarios of power allocation levels, target rates, and imperfections. The transmit SNR and power allocation of the users are important for efficient communication in any fading distribution as shown in this paper.

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1. INTRODUCTION

The introduction of the non-orthogonal multiple access (NOMA) technique has paved way for massive device connectivity among the network. NOMA has become the most viable option to be implemented in 4th generation (4G) networks and beyond [1]. NOMA has the ability to serve multiple users in the same cluster using the same resources. It transmits the signal by superimposing the users' signals, which also leads to improved spectral efficiency. At the receiver, the superimposed signals are separated by performing successive interference cancellation. During the signal transmission, the channel state information (CSI) of the users might be known or unknown. The implementation and integration of NOMA with various emerging and trending technologies and techniques have become mandatory to achieve efficient results in various system models. One of the most important parameters to be considered for a quality signal transmission is its fading channel distribution. There are various fading channels such as rayleigh, rice, rician, and nakagami-*m*, which are proved to be efficient in the radio environment when optimized.

Relate work, Wan *et al*. [2] have considered downlink cooperative non-orthogonal multiple access NOMA (C-NOMA) network under nakagami-*m* fading channels to investigate the outage performance and sum-rate of the system. A similar system was considered in [3] in presence of the Rician fading channel and the performance was evaluated in terms of achievable rate. Fara and Kaya [4] proposed a downlink and uplink NOMA network over the rayleigh fading channel in presence of SIC errors. The performance of the system was evaluated in terms of bit error rate (BER). Yin *et al*. [5] investigated the performance of NOMA2000 and power domain NOMA (P-NOMA) and the compared results show that P-NOMA has yielded better results than NOMA2000. Different from the remaining articles, Sharma *et al*. [6] considered generalized fading channels $(\eta - \mu)$ and $(\kappa - \mu)$ in a downlink NOMA network. The performance was investigated in terms of outage probability by keeping the fixed target rate. When the results are compared with OMA, NOMA, shows a better performance rate. Also, it is noticed that the performance keeps getting better with the increase in signal-to-noise ratio (SNR). Similar to [2], the outage performance of C-NOMA was investigated over log-normal fading distribution in [7]. Secrecy performance was investigated on a similar model in [8]. NOMA has also been integrated with various technologies which have improved its operational efficiency. Elhattab *et al*. [9] proposed reconfigurable intelligent surfaces (RIS)-assisted C-NOMA in both half-duplex and full-duplex modes. The authors have proposed an efficient algorithm to minimize the power consumption at both the base station and the receiver. Visible light communication (VLC) is also another emerging technology which has immense capacity to perform quality signal transmission underwater. Elamassie *et al*. [10] employed VLC-based wireless sensor network using NOMA technique to perform system capacity analysis over log-normal distribution. Cao *et al*. [11] integrated millimeter wave (mmWave) with NOMA to achieve massive device connectivity and improved data transmission secrecy. The authors have proposed two schemes based on joint user grouping and power optimization which are shown to be efficient in enhancing the system performance. The presence of single and multiple eavesdropper scenarios was considered in [12] to analyze the performance of NOMA network in ground-to-air communications. The performance was investigated in terms of secrecy outage probability (SOP).

Fu *et al*. [13] proposed integration of RIS with the NOMA technique, aiming to minimize the transmit power by optimizing the order of users, beamforming vectors, and phase shift matrix. The authors have proposed a difference-of-convex algorithm to solve non-convex problems and an efficient user-ordering scheme to enhance the target data rates. A similar system design was proposed in [14] to optimize the rate of performance and user fairness in the network. Efficient algorithms were proposed to deal with the non-convex algorithms and obtained results are comparatively more efficient than traditional system models. Whereas in [15], multiple RIS-assisted NOMA networks in presence of discrete phase shifts are investigated to enhance the signal quality of each user present in the network. Direct link and no direct link with each user scenario was considered and the performance was analyzed in terms of outage probability. Research by Khan *et al*. [16], NOMA-assisted vehicle-to-everything (V2X) communications were proposed in presence of back-scattering to enhance the achievable rates through cooperation between the devices. Optimal power allocation schemes were introduced in the network to enhance the communication between the base station and roadside units that acts as a bridge for vehicles to communicate. In a scenario of industrial IoT, the NOMA technique is proposed to enhance the connectivity of a number of ultra-reliable low latency (URLLC) devices in [17]. Regarding data analysis, topological data analysis (TDA), is now a promising new area of data mining research in V2X communications [18]. The proposed model allows multiple URLLCs to keep connected and transmit data simultaneously across the multiple frequency channels. The performance of each user pair or cluster is analyzed in terms of achievable sum rates. The studies provide important inputs to the research as each paper provides detailed performances of the system in various scenarios. In the perspective of real-world implementations, most of the research works considered only ideal cases such as perfections in all parameters. Therefore, this research has a different perspective and our considered model will be approximate to the real-world implementation.

Motivation and organization, as mentioned, most of the research works are based on the ideal case situations which are meant to be changed when implemented in the real world. Therefore, we are motivated to analyze the performance of the below-proposed model while it is facing a few imperfections during the transmission process. It is important to understand and investigate the performance of various models. As of the above studies, NOMA has been studied in various fading environments such as rayleigh, rician and log-normal. But, particularly in log-normal, there is no dedicated study to analyze its performance in presence of channel estimation errors and imperfect SIC. Therefore, in this paper, we propose a model based on the NOMA network over log-normal fading distribution in presence of both perfect and imperfect SIC. The performance of the system was studied in terms of outage probability and in-depth discussions are provided in the following sections. The major contributions of this paper are as:

– Deriving closed-form outage probability expressions for the proposed model in presence of channel estimation errors and imperfect SIC.

- Computing the throughput expression based on the outage probability expressions derived.
- Simulating the expression in MATLAB with assistance with monte-carlo simulation verifying the authenticity of obtained expressions.
- Analyzing the effects of channel estimation errors and imperfect SIC in NOMA network over log-normal fading effect.

The remaining of the paper is as: section 2 introduces and describes the system model and its characteristics. Section 3 provides the computations based on outage probability and section 4 provides the computations for throughput of the system. Section 5 provides the numerical analysis with simulations and in-depth discussions on it. Finally, section 6 concludes the paper.

2. SYSTEM MODEL AND CHANNEL CHARACTERISTICS

2.1. System model

As shown in Figure 1, we consider a NOMA network in presence of a base station (BS) communicating with two users D_1 and D_2, with single antennas at both users, which does not have any direct link between the two users. The considered links, from BS to users, are estimated to be following log-normal fading with channel coefficients g_1 and g_2 at respective users. Due to imperfect CSI, the estimated channel gains of the relay-user links are given as [19].

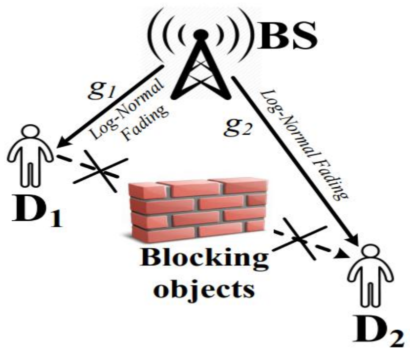

Figure 1. System model of downlink two users NOMA

$$\hat{\square}_j = \square_j + e_j \quad ,j \in \{1,2\} \tag{1}$$

Where $e_j \sim CN(0, \Omega_e)$ is the channel estimation error and $\square_j$ is the estimated channel coefficients [20]. The received signal at the two NOMA users, D_1 and D_2 are given by [21]

$$y_1 = \hat{\square}_1 \sqrt{P_S} \left(\sum_{j=1}^{2} \sqrt{v_j} x_j \right) + \omega_1 = (\square_1 + e_1) \sqrt{P_S} \left(\sum_{j=1}^{2} \sqrt{v_j} x_j \right) + \omega_1 \tag{2a}$$

$$y_2 = \hat{\square}_2 \sqrt{P_S} \left(\sum_{j=1}^{2} \sqrt{v_j} x_j \right) + \omega_2 = (\square_2 + e_2) \sqrt{P_S} \left(\sum_{j=1}^{2} \sqrt{v_j} x_j \right) + \omega_2 \tag{2b}$$

Where P_S denotes the normalized transmission power at the base station (BS), ω_1 and ω_2 denotes the additive white gaussian noise (AWGN) at the node D_1 and D_2, respectively, and x_j is assumed to be normalized the unity power signal for the *j*-th user, i.e., $\mathbb{E}\{x_j^2\} = 1$ in which E is the expectation operator. The *j*-th user's power allocation factor v_j satisfies the relationship $v_2 > v_1$ with $\sum_{j=1}^{2} \sqrt{v_j} = 1$, which is for the sake of user fairness. Meanwhile, the noise terms are additive white gaussian noise (AWGN) with zero mean and variance of N_0. In the first phase, the signal to interference-plus-noise ratio (SINR) after treating x_1 as interference is given by:

$$\Gamma_{D_1, x_2} = \frac{v_2 \rho_S |\square_1|^2}{1 + \rho_S \Omega_e + v_1 \rho_S |\square_1|^2} = \frac{v_2 \rho_S \gamma_1}{1 + \rho_S \Omega_e + v_1 \rho_S \gamma_1}, \tag{3}$$

Where $\gamma_i \overset{\Delta}{=} |\square_i|^2, i \in \{1,2\}$ and the transmit signal to noise ratio (SNR) computed at the BS as $\rho_S = \frac{P_S}{N_0}$. Note that γ_1 and γ_2 are independent RVs. It is worth noting that imperfect SIC (ipSIC) occurs, the SINR of detect x_2 is given as [22]

$$\Gamma_{D_1,x_1}^{ipSIC} = \frac{v_1\rho_S\gamma_1}{1+\rho_S\Omega_e+\rho_S|\square_I|^2}, \quad (4)$$

Where $|\square_I|^2 \sim CN(0,\lambda_I)$ in [23], with $\lambda_I (0 \leq \lambda_I < 1)$ denotes as the level of residual interference caused by imperfect SIC and $CN \sim (a,b)$ complex normal distribution with average a and variance b. Similarly, the instantaneous SINR at D_2 to detect x_2 is given as:

$$\Gamma_{D_2,x_2} = \frac{v_1\rho_S\gamma_2}{1+\rho_S\Omega_e+v_2\rho_S\gamma_2} \quad (5)$$

2.2. Channel characteristics

Let $\sigma_{\square,\text{dB}}^2 = \sigma_{\square_1,\text{dB}}^2 = \sigma_{\square_2,\text{dB}}^2$ and $\mu_{\square,\text{dB}} = \mu_{\square_1,\text{dB}} = \mu_{\square_2,\text{dB}}$ are the mean and variances of $10\,log\,\square_i$, $i \in \{1,2\}$, respectively. Now $\gamma = \gamma_1 = \gamma_2$ has log-normal fading probability density function (PDF), which is given by [24], in (1)

$$f_\gamma(x) = \frac{\xi}{x\sqrt{2\pi\sigma_{z_{\square,\text{dB}}}^2}} e^{-\frac{\left(\xi\, ln\, x - \mu_{z_{\square,\text{dB}}}\right)^2}{2\sigma_{z_{\square,\text{dB}}}^2}}, \quad (6)$$

Where $\xi = \frac{10}{ln\,10}$, $ln\,x$ denote the natural logarithms, $\sigma_{z_{\square,\text{dB}}}^2 = \text{var}\left(z_{\square,\text{dB}}\right) = 4\sigma_{\square,\text{dB}}^2$ and $\mu_{z_{\square,\text{dB}}} = E\left(z_{\square,\text{dB}}\right) = 2\mu_{\square,\text{dB}}$, $\text{var}(x)$ and $E(x)$ denote the variance and the expectation, respectively. The cumulative distribution functions (CDF) of γ can be obtained as:

$$F_\gamma(x) = \int_0^x f_\gamma(y)dy = \frac{\xi}{\sqrt{2\pi\sigma_{z_{\square,\text{dB}}}^2}} \int_0^x \frac{1}{y} e^{-\frac{\left(\xi\, ln\, y - \mu_{z_{\square,\text{dB}}}\right)^2}{2\sigma_{z_{\square,\text{dB}}}^2}} dy, \quad (7)$$

By the change of variable $t = ln(y) \to dt = \frac{dy}{y}$ in (7), the CDF moments can be rewritten as:

$$F_\gamma(x) = \frac{\xi}{\sqrt{2\pi\sigma_{z_{\square,\text{dB}}}^2}} \int_{-\infty}^{\ln x} e^{-\frac{\left(\xi t - \mu_{z_{\square,\text{dB}}}\right)^2}{2\sigma_{z_{\square,\text{dB}}}^2}} dt \quad (8)$$

After some manipulations, the last integral can be rewritten as:

$$F_\gamma(x) = \frac{\xi}{2}\left[\text{erf}\left(\frac{\xi\, ln\, x - \mu_{z_{\square,\text{dB}}}}{\sigma_{z_{\square,\text{dB}}}\sqrt{2}}\right) + 1\right] = \frac{\xi}{2}\text{erfc}\left(-\frac{\xi\, ln\, x - \mu_{z_{\square,\text{dB}}}}{\sigma_{z_{\square,\text{dB}}}\sqrt{2}}\right), \quad (9)$$

Where $\text{erf}(x) = \frac{2}{\sqrt{\pi}}\int_x^{+\infty} e^{-y^2}dy$ is the complementary error function in [25], (8.250.1)]. Following that, we have $|\square_I|^2$'s PDF and CDF in [26]:

$$f_{|\square_I|^2}(x) = \frac{1}{\lambda_I} e^{-\frac{x}{\lambda_I}}, \quad (10)$$

and

$$F_{|\square_I|^2}(x) = 1 - e^{-\frac{x}{\lambda_I}} \quad (11)$$

3. ANALYSIS OF OUTAGE PROBABILITY

First, the outage probability with imperfect SIC (ipSIC) of D1 is calculated as:

$$P_{D_1}^{ipSIC} = 1 - Pr\left(\Gamma_{D_1,x_2} > \varepsilon_2, \Gamma_{D_1,x_1}^{ipSIC} > \varepsilon_1\right) = 1 - Pr\left(\gamma_1 > \delta_2, \gamma_1 > \delta_1(\rho_S|\square_I|^2 + \ell_e)\right), \quad (12)$$

Where $\varepsilon_i = 2^{2R_i} - 1$ for $i = 1,2$ is called as target rate at $\ell_e = (\rho_S\Omega_e + 1)$, $\delta_2 = \frac{\varepsilon_2\ell_e}{\rho_S(v_2 - v_1\varepsilon_2)}$ and $\delta_1 = \frac{\varepsilon_1}{v_1\rho_S}$. Assuming $\delta_1(\rho_S|\square_I|^2 + \ell_e) \gg \delta_2$, OP_1 can be calculated by:

$$P_{D_1}^{ipSIC} = 1 - Pr\left(\gamma_1 > \delta_1(\rho_S|\square_I|^2 + \ell_e)\right) = 1 - \int_0^\infty f_{|\square_I|^2}(x)\left[1 - F_{\gamma_1}\left(\delta_1(\rho_S x + \ell_e)\right)\right]dx. \quad (13)$$

We using PDF of (10) and CDF of (9), (13) is given as:

$$P_{D_1}^{ipSIC} = 1 - \int_0^\infty f_{|\square_I|^2}(x)\left[1 - F_{\gamma_1}\left(\delta_1(\rho_S x + \ell_e)\right)\right]dx = 1 - \frac{1}{\lambda_I}\int_0^\infty e^{-\frac{x}{\lambda_I}}\left[1 - \frac{\xi}{2}\text{erfc}\left(-\frac{\xi\, ln\left(\delta_1(\rho_S x + \ell_e)\right) - \mu_{z_{\square,\text{dB}}}}{\sigma_{z_{\square,\text{dB}}}\sqrt{2}}\right)\right]dx = \frac{\xi}{2\lambda_I}\int_0^\infty e^{-\frac{x}{\lambda_I}}\text{erfc}\left(-\frac{\xi\, ln\left(\delta_1(\rho_S x + \ell_e)\right) - \mu_{z_{\square,\text{dB}}}}{\sigma_{z_{\square,\text{dB}}}\sqrt{2}}\right)dx \quad (14)$$

Let $r = \frac{4}{\pi}arctan(x) - 1 \Rightarrow tan\left(\frac{\pi(r+1)}{4}\right) = x \Rightarrow \frac{\pi}{4}\sec^2\left(\frac{\pi}{4}(r+1)\right)dr = dx$ in which $\sec^2(\times) = \frac{1}{cos^2\,(x)}$, $P_{D_1}^{ipSIC}$ is given as:

$$P^{ipSIC}D_1 = \frac{\xi}{2\lambda_1}\int_0^\infty e^{-\frac{x}{\lambda 1}} erfc\left(-\frac{\xi \text{In}\left(\delta_1(P_S X + \ell_e)\right) - \mu Zh_{dB}}{\sigma Zh_{,dB}}\right)dx = \frac{a\pi\xi}{8\lambda_1}\int_{-1}^1 sec^2\left(\frac{\pi}{4}(r + 1)\right) e^{-\frac{1}{\lambda 1}tan}\left(\frac{\pi(r+1)}{4}\right)\text{erfc}\left(-\frac{\xi \text{In}\left(\rho_S\delta_1 \tan\left(\frac{\pi(r+1)}{4}\right) + \ell_e\delta_1\right) - \mu_{zh.dB}}{\sigma Zh_{,dB}\sqrt{2}}\right)dr. \quad (15)$$

Though it is difficult to derive a closed-form expression for (15), we can obtain an accurate approximation for it. In step (a) is achieved by applying the gaussian-chebyshev quadrature [27], (25.4.38)]. Now we have $P_{D_1}^{ipSIC}$ is given by:

$$P_{D_1}^{ipSIC} \approx \frac{\pi^2\xi}{8K\lambda_I}\sum_{k=1}^K\sqrt{1 - \xi_k^2}\, sec^2\left(\pi 4^{-1}(\xi_k + 1)\right)e^{-\frac{tan\left(\pi 4^{-1}(\xi_k+1)\right)}{\lambda_I}} \times \text{erfc}\left(-\frac{\xi\, ln\left(\rho_S\delta_1\, tan\left(\pi 4^{-1}(\xi_k+1)\right) + \ell_e\delta_1\right) - \mu_{z_{\square,\text{dB}}}}{\sigma_{z_{\square,\text{dB}}}\sqrt{2}}\right), \quad (16)$$

Where $\xi_k = cos\left(\frac{2k-1}{K}\pi\right)$

Specifically, assume $\lambda_I \to 0$ then $|\square_I|^2 \approx 0$, we have the outage probability with pefect SIC (pSIC) $P_{D_1}^{ipSIC}$ is calculated as:

$$P_{D_1}^{pSIC} = 1 - Pr\left(\frac{v_2\rho_S\gamma_1}{1+\ell_e+v_1\rho_S\gamma_1} > \varepsilon_2, v_1\rho_S\gamma_1 > \ell_e\varepsilon_1\right) = 1 - Pr(\gamma_1 > \delta_2, \gamma_1 > \ell_e\delta_1) = 1 - Pr(\gamma_1 > \delta_{max}()) \quad (17)$$

Where $\delta\, max(_{2_{e_{1_{max}}}}$. With the help of (9), $P_{D_1}^{ipSIC}$ is given as:

$$P_{D_1}^{pSIC} = 1 - Pr\,(\gamma_1 > \delta_{max}) = F_{\gamma_1}(\delta_{\text{max}}) = \frac{\xi}{2}\text{erfc}\left(-\frac{\xi \text{In}\ \delta_{max} - z_{\square,\text{dB}}}{\sigma_{z_{\square,\text{dB}}}\sqrt{2}}\right) \quad (18)$$

Finally, similar to P_{D_1} the outage probability of D_2 is calculated as:

$$P_{D_2} = 1 - Pr\left(\Gamma_{D_2,x_2} > \varepsilon_2\right) = 1 - Pr\left(\frac{v_1\rho_S\gamma_2}{1+\ell_e+v_2\rho_S\gamma_2} > \varepsilon_2\right) = 1 - Pr(\gamma_2 > \delta_2) = F_{\gamma_2}(\delta_2) = \frac{\xi}{2}\text{erfc}\left(-\frac{\xi\, ln\,\delta_2 - \mu_{z_{\square,\text{dB}}}}{\sigma_{z_{\square,\text{dB}}}\sqrt{2}}\right) \quad (19)$$

4. SYSTEM THROUGHPUT ANALYSIS

The system model can be further evaluated using system hroughput calculations with ipSIC and pSIC using outage probabilities. Throughput can be achieved in latency limited mode at the set target rate as follows:

$$\tau_{sys}^{ipSIC} = \left(1 - P_{D_1}^{ipSIC}\right)R_1 + \left(1 - P_{D_2}\right)R_2, \quad (20a)$$

$$\tau_{sys}^{pSIC} = \left(1 - P_{D_1}^{pSIC}\right)R_1 + \left(1 - P_{D_2}\right)R_2 \tag{20b}$$

5. NUMERICAL RESULTS

In this section, we numerically simulate some theoretical results from some figures to show the outage performance. In particular, the main parameters can be seen in Table 1. In addition, the Gauss-Chebyshev parameter is selected as $K = 150$ to yield a close approximation. Figure 2 demonstrates the OP versus transmit SNR of the proposed model in presence of ideal and imperfections at SIC. As we can clearly observe that as the imperfections reduce, the performance of the user increases comparatively. The far user has the better performance compared to a near user in both cases because the power allocation to the far user is highest. Also, the simulations indicate that analytical and exact simulations are tightly packed with each other which verifies the correctness of the obtained expressions in section 3.

Table 1. System parameters used in the performance evaluation

System parameters	Values
Monte Carlo simulations repeated	10^7 iterations
The power allocation coefficients	$\{v_1, v_2\} = \{0.2, 0.8\}$
The target rate at D_1	$R_1 = 1$bps/Hz
The target rate at D_2	$R_2 = 0.5$bps/Hz
The interference signal channel power gains	$\lambda_I = 0.01$
The channel estimation error	$\Omega_e = 0.01$
The mean value of $10\,log(\lvert\square_i\rvert^2)$	$\mu_{g_1} = \mu_{g_2} = 4dB$
The standard deviation of $10\,log\left(\lvert\sigma_{g_i}\rvert^2\right)$	$\sigma_{g_1} = \sigma_{g_2} = 5dB$

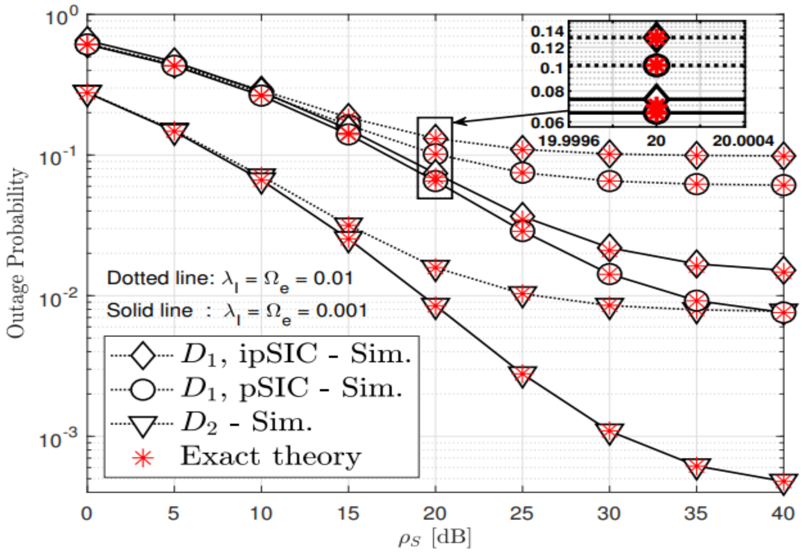

Figure 2. Outage probability versus transmit SNR in presence of imperfections

Figure 3 shows the simulation between OP versus power allocation at D_1 for a fixed level of imperfections in the system, which can be considered negligible. As we can observe, as the power level increases for D_1, the performance of the user increases, and the performance of D_2 reduces simultaneously. This is because the power allocation in NOMA follows the condition $v_1 + v_2 = 1$. As the power allocation becomes equal for both users at $v_1 = v_2 = 0.5$, the performance of both users becomes equal and the curves converge at the particular point. Another important point to be noticed is the effect of transmit SNR. As we can observe a huge gap between the curves, this is because of the change in transmit SNR. As the transmit SNR increases, the quality of signal transmission increases, leading to a better outage probability for the user.

Similar to Figure 3, Figure 4 demonstrates the simulation between OP and different levels of target rates assigned to the users in the network. The analysis was performed for two different transmit SNR values. We can observe that D_2 has shown better performance for overall simulation because of the highest power allocation to it. Whereas at D_1, the perfect and imperfect SIC levels are considered with a minute difference and the change in the performance can be observed clearly. The maximum target rate of the system is 2 and the performance of the users increases comparatively as we reduce the target rates. As the transmit SNR increases, the performance of the users in all scenarios increases as it shows the quality of signal transmitting.

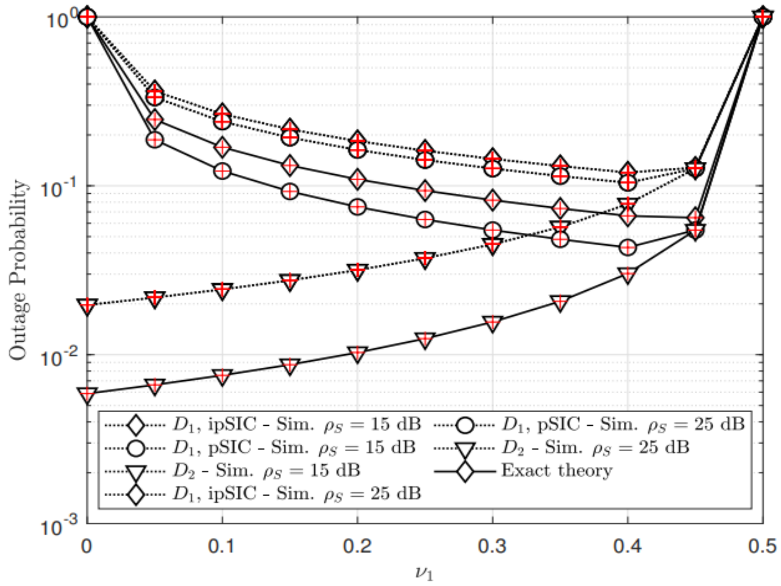

Figure 3. Outage probability versus υ_1, with $\lambda_I = \Omega_e = 0.01$

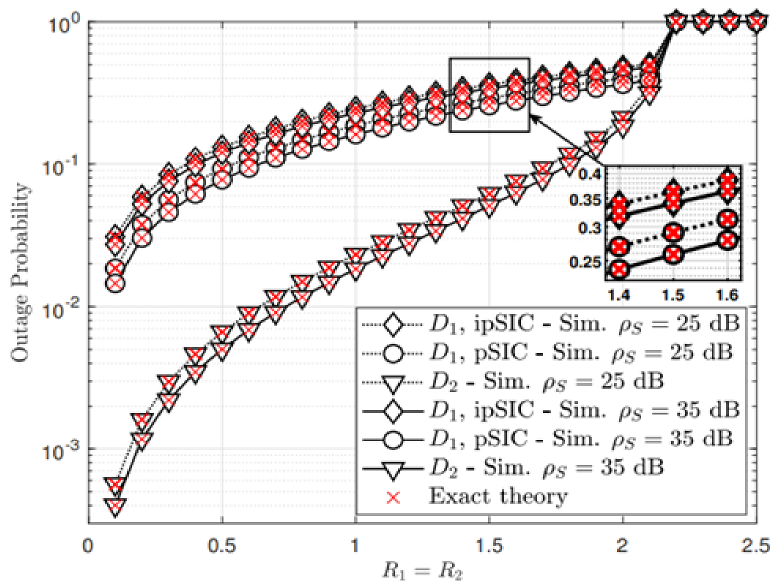

Figure 4. Outage probability versus $R_1 = R_2$, with $\lambda_I = \Omega_e = 0.01, \nu_1 = 0.05$and $\nu_2 = 0.95$

Finally, Figure 5 demonstrates the throughput performance of the system for various levels of imperfections, keeping the target rate at maximum for both the users. As we can observe from the system, with the level of imperfections increasing, the throughput performance of the system is decreasing rapidly. The observation shows that though the increased imperfections are noticeable, the change of the performance is stable which indicates the ability of fading distribution to compensate for the effects. Also, the transmit SNR plays a vital role, as the transmit SNR increases, the performance changes for the scenarios.

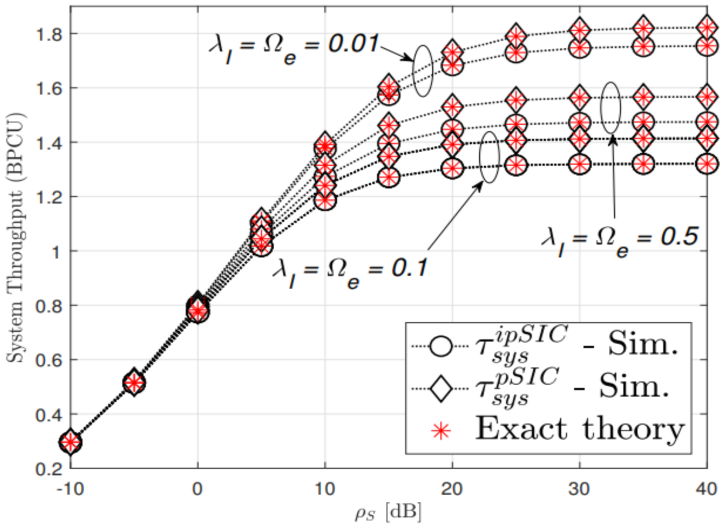

Figure 5. System throughput, with $\nu_1 = 0.05, \nu_2 = 0.95$ and $R_1 = R_2 = 2$

6. CONCLUSION

In this paper, we have considered a NOMA network with two users D_1 and D_2 over log-normal fading distribution. The considered model is expected to be facing imperfections in CSI and SIC. The performance was analyzed in terms of outage probability and throughput of the system. The obtained expressions are simulated in aid with the Monte-Carlo method, to verify the correctness of computations, and the simulations show that the analytical and simulation are tightly packed with each other. From the simulation analysis, it can be clearly understood that the transmit SNR and power allocation to the user play a pivotal role in enhancing the performance of users. The role of imperfections is also shown in the simulations where, for minute change in the level of imperfection, the change in performance is also considerably observable. Finally, the proposed model has shown significant performance compared to other system models in various researches over different fading distributions and with the presence of imperfections.

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